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Understanding Kabwe's Lead Pollution

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Understanding Kabwe's Lead Pollution

by

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Dedication

To the residents of Kabwe.

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Abstract

Understanding Kabwe's Lead Pollution

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The University of Texas at Austin, 2014

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To understand why Kabwe, Zambia is one of the most lead polluted towns, one has to look at the source of this pollution and its extent. With a history of poor environmental regulation, policies, and public information, the lead pollution caused by mining activities in Kabwe went unmitigated for decades. The natural blood-lead level in humans is about 0.0016 μg/dl, in developed countries like the United States, strict enforcement has resulted into lead levels averaging figures below 10 μg/dl, but in Kabwe, averages lie between 60 μg/dl and 120 μg/dl. Levels over 10 μg/dl are unhealthy, while levels above 20 μg/dl can cause acute poisoning, whereas levels over 120 μg/dl often result into death. New environmental and rehabilitation laws were only enacted after a new administration came into office in 1991; however, additional mitigation measures such as obtaining a reclamation bond prior to being issued a mining permit need to be considered.

Key Words: Mining, Pollution, Unmitigated, Blood-Lead, Laws, Rehabilitation.

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Introduction:

Zambia gained its independence in 1964 with copper mining being the mainstay of its economy. Throughout the 1970s and 1980s, the mining industry was the country's second largest employer after the government, and generated about 85 percent of Zambia's foreign exchange, 30 percent of government revenue, and 15 percent of Zambia's Gross Domestic Product.[1] Shortly after independence, the Government of Zambia embarked on a policy of nationalizing key sectors of its economy, which also included the mining sector. In 1973 the government assumed control of the mining industry, and later on in 1982 created the Zambia Consolidated Copper Mines (ZCCM), a state-owned mining company.[2] As this transformation was happening, the commodity boom of the 1980s was also starting to end, and hence lead to the falling prices of copper.[3] Since a substantial part of government revenues came from mining, this meant that dwindling ZCCM profits would be affected by the falling copper prices and the profit allocations it gave to the government.

In the early 1990s, right after a new administration led by Frederick Chiluba had assumed office, the Government of Zambia decided to initiate the privatization of ZCCM. The new administration envisioned that privatization would increase the efficiency of the mining industry, attract foreign investment, and boost the development of the private sector; soon after ZCCM's privatization, its remnants were transformed into an

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[1] World Bank." *Zambia - Copperbelt Environment Project."* Washington, DC: World Bank, 2003, 4. http://documents.worldbank.org/curated/en/2003/02/2155606/zambia-copperbelt-environment-project
[2] Ibid.
[3] Ibid.

investment holding company, ZCCM-Investment Holding (ZCCM-IH); this company also became a minority shareholder in the newly privatized mining, processing, and electric power companies.[4] For the purposes of this report, the privatization of ZCCM was seen as a major turning point that provided the basis to improving Zambia's environmental laws that had been ignored for decades by both the government and the pioneering mining entities.

This report will however specifically focus on ZCCM's lead and zinc mining operation in Kabwe and how both nationalization and privatization policies contributed to the town's lead pollution. Prior to 1991 most of Zambia's mining industry was nationalized, and because of this there was no deliberate effort by the government to put in place public information and education about the lead poisoning that was happening in Kabwe. It was not until the Chiluba administration assumed office in 1991 with a new agenda to privatize the mining industry, did the country see an unprecedented policy change towards public information regarding mining pollution. Whether this change in policy regarding public information on pollution was willingly made, or not, by the government is open for debate, but the fact of matter is that more good resulted from this policy change because it brought awareness to the lead pollution that was occurring in Kabwe. More importantly however, was that these new policies led to the discussion of how to address the environmental mortgage ZCCM had left behind in Kabwe after its closure.

[4] World Bank. 4.

The genesis of this report however stems from a 2007 *Time Magazine* article that referenced a Black Smith Institute report on Kabwe's lead pollution. This article listed Kabwe as one of the most polluted places on the planet.[5] In order to understand the seriousness of this claim, context is needed, and to provide this context, this report has compared lead poisoning blood levels in the United States, to those found in Kabwe. The natural blood-lead levels in humans, is approximately 0.0016 μg/dl (micrograms per deciliter), but the acceptable normal levels are currently pegged at 10 μg/dl.[6] The U.S. has been found to generally have normal lead-blood concentrations of less than 10 μg/dl, where as in Kabwe, levels as high as 300 μg/dl were found. "Symptoms of acute [lead] poisoning occur at [concentrations] of 20 μg/dl and above, hence resulting in vomiting [and] diarrhea [which further causes] muscle spasms and kidney damage. Levels over 10 μg/dl are considered unhealthy and levels in excess of 120 μg/dl can often lead to death. In Kabwe, concentrations of 300 μg/dl have been recorded in children [even though] records show that the average [lead concentrations in the] blood [of] children ranges between 60 μg/dl and 120 μg/dl."[7]

Lead is a cumulative toxicant that affects multiple body systems and is particularly harmful to young children, and when it enters the body, it is distributed to the

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[5] Walsh, Bryan. *"The World's Most Polluted Places*." Time Magazine, New York, 2007.http://content.time.com/time/specials/2007/article/0,28804,1661031_1661028_1661016,00.html

[6] Chukwuma, Sr, Chrysanthus. "*Environmental Lead Exposure in Africa*." Ambio, Vol. 26, No. 6, Springer (1997): 399-403, 400.

[7] Blacksmith Institute. *"Kabwe's Legacy of Lead."* (New York, NY: Blacksmith Institute, 2003). http://www.blacksmithinstitute.org/projects/display/3.

brain, liver, kidney, nervous system and bones.[8] In the human body, lead commonly accumulates and stores in the teeth and bones; however, the contamination of the human body to lead is commonly determined and assessed through the testing of blood.[9] Lead is undoubtedly one of the most potent neurotoxins, and because of its negligent mining in Kabwe, the town has found its human and environmental health contaminated.

With this brief overview of the mining industry in Zambia and the lead pollution in Kabwe, the fundamental questions this report will try to address are firstly: How did Kabwe find itself to being one of the most polluted places on the planet, and secondly, to what extent did the lead pollution contaminate Kabwe's human and environmental health? This paper will also show how both nationalization and privatization policies impacted Zambia's environmental regulation and management practices. The main objective of this report is to hopefully enlighten the reader on gaining a better understanding of the factors that arguably led Kabwe to have such high levels of lead pollution and contamination, and secondly to sensitize the reader on how lead poisoning affects human health.

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[8] WHO. "*Lead Poisoning and Health*." World Health Organization, 2013. http://www.who.int/mediacentre/factsheets/fs379/en/.
[9] Ibid.

Nationalizing the Mining Industry:

The late 1960s were marked with an increase in the nationalization of foreign owned businesses operating in Asia, Africa, and Latin America, and especially in countries that had their natural resources owned and operated by foreign private concerns.[10] In some places where nationalization had stemmed from the decolonization process, there had been a smooth transfer of ownership, as was the case in 1946 when Juan Domingo Peron acquired the British owned Argentine railroads.[11] In other instances this had not been the case; in Zambia for example, there were strong sentiments of nationalization targeted towards foreign owned mining companies after independence because they were seen to be the last vestiges of colonization.[12] As an idea, nationalization in Zambia was merely a reflection of the mood and sentiments Zambians had towards their former British colonial masters after gaining independence. During this period, these newly formed governments in the developing world were filled with optimism to taking control of their economies; in Zambia for example, the foreign mining companies that operated the mining industry, had been "invited" by the newly independent government to offer part of their equity to the state.[13] The principal reason behind the Zambian Government's taking over the mining industry, was its desire to

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[10] Chick, Martin. "*Nationalization*." History of World Trade Since 1450. Ed. John J. McCusker. Vol. 2. Detroit: Macmillan Reference USA, 2006. 521-524. Gale Virtual Reference Library, 522. http://go.galegroup.com/ps/i.do?id=GALE%7CCX3447600294&v=2.1&u=txshracd2598&it=r&p=GVRL&sw=w&asid=975794d31df7d3391b2759e6b34f0fa6

[11] Chick, 522.

[12] Cunningham, Simon. *"The Copper Industry in Zambia: Foreign Mining Companies in a Developing Country."* New York, NY: Praeger, 1981. Print, 269.

[13] Chick, 523.

control the industry's finances, especially when it came to the profits that were being repatriated at the expense of reinvestment in Zambia by the foreign mining concerns.

On the 11th of August 1969, the Zambian Government "invited" Roan Selection Trust (RST) and Anglo American Corporation (ACC), the two mining companies operating and controlling the mining industry in Zambia at the time, to sell 51 percent of their shares to the government.[14] A few years later, on August 31st, 1973, then head of state and government President Kenneth Kaunda, announced that the government was also taking over the management and marketing of the copper mining industry; to attain this control, the government initiated a series of reforms, the first being the Mulungushi Reforms of 1968, then the Matero Pronouncements of 1969, the November 10th economic reforms of 1970, and finally the announcement of August 31st 1973 that gave the government control of the mining operations.[15]

Other than for reasons of wanting to gain economic control of the mining industry and the removal of British symbols that reminded Zambians of colonialism, there were also other political and personal reasons that led to nationalizing the mines. One might say that President Kaunda's timing in announcing the government's majority acquisition of the mines was also motivated by political reasons. President Kaunda had seen mounting dissension within his own party and cabinet that had increasingly questioned his leadership, so in order to restore his diminishing support, Kaunda started a campaign

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[14] Simwinga, George. "*The Copper-Mining Industry of Zambia: A Case Study of Nationalization and Control.*" What Government Does. Ed. Dennis L. Dressing, and Matthew Holden. Vol.1. Beverly Hills CA: Sage Publications, 1975, 84.
[15] Simwinga, 85.

of national unity, and to do this, he used the platform of nationalizing foreign mining companies that were seen by the majority of the population as remnants and reminders of colonialism.[16]

Despite Kaunda's personal reasons to nationalize the mining industry, the Zambian Government still found little reason to trust foreign companies after independence, especially due to their repatriation of profits and the lack of substantial reinvestment in Zambia. In 1973, the government finally took over the management and operation of the foreign mining companies and paid the previous owners in full amount for the 51 percent equity the government had acquisitioned and any outstanding debt.[17] This action taken by the government further led to the establishment of two state-owned companies, Roan Consolidated Mines (RCM) and Nchanga Consolidated Copper Mines (NCCM), to fill the vacuum left behind by Roan Selection Trust and Anglo-American Corporation in the mining industry.[18] In 1982, the two state-owned companies RCM and NCCM were then merged to form Zambia Consolidated Copper Mines (ZCCM), which also owned and operated the lead and zinc mining operation in Kabwe, of which this report will be focusing on.

[16] Simwinga, 86.
[17] Simwinga, 92.
[18] Ibid.

The Mineral Lead:

Lead, whose chemical symbol is Pb from the abbreviated Latin word *plumbum*, is a corrosion-resistant, dense, ductile, and malleable blue-gray metal, often found in the naturally occurring lead sulfide mineral ore also known as Galena.[19] Lead is formed and found in different types of rock deposits which include: ingenuous, metamorphic, and sedimentary rocks; the sedimentary deposits of lead can occur as vein, isolated grain, or as replacement deposits in carbonate rocks such as limestone and dolostone.[20] The carbonate replacement deposits are what this report will deem relevant because they fit the description of the type of lead deposits at the Kabwe Mine. Before the lead mine was closed in Kabwe, the mineral deposits mainly consisted of a core body of lead sulfide ore, which was surrounded or hosted by the carbonate rock dolomite.[21] This carbonate rock that hosted the lead, also played a very important role of acting as a buffer in preventing the contamination of water by lead pollutants.[22]

Archeological research indicates that for over 5,000 years, humans have found uses for lead, from water pipes that date back to the Romans, to making ammunition, and

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[19] Kropschot, S.J, and Jeff L. Doebrich. "*Lead- Soft and Easy to Cast*." United States Geological Survey (USGS), 2011, 1. http://pubs.usgs.gov/fs/2011/3045/.

[20] King, Hobart. "*Galena*." Geology.com: Geosciences News and Information (2013). http://geology.com/minerals/galena.shtml.

[21] Leteinturier, B., J. Laroche, J. Matera, and F. Malaisse. "*Reclamation of Lead/Zinc Processing Wastes at Kabwe, Zambia: A Phytogeochemical Approach*." South African Journal of Science 97 (2001): 624-627, (2014), 624.

[22] Kamona, A.F., and G.H. Friedrich. *"Geology, Mineralogy and Stable Isotope Geochemistry of the Kabwe Carbonate-Hosted Pb-Zn Deposit, Central Zambia."* Ore Geology Reviews, 2007, 30: 217-243, 218.

paint in the 1900s; its demand further increased with its use in motor vehicles and battery production, as well as, its use as an additive to gasoline.[23]

This report will however show that the lead poisoning that was happening in Kabwe was mostly through the exposure pathways of soil, air, and vegetation contamination. Today however, and especially in the United States, there have been many regulatory restrictions in the uses of lead due to its toxic nature, but in other places like Zambia, it has been poor regulations that had played a key role in allowing lead to contaminate both the human and environmental health of Kabwe, especially to those living near the mining areas and had direct exposure to the lead pollution that was coming from the mining operations owned by ZCCM.

[23] Kropschot, 2011.

The Effects of Lead on Human Health:

Exposure pathways are the sources by which humans come in contact with the lead and these pathways generally include soil, dust, water, and foodstuff; exposure routes on the other hand are how humans get contaminated by the lead substances, and this can be through inhalation, ingestion, and skin or eye contact.[24] The dosage and the duration of exposure also play a key role in potential health effects of lead poisoning because recent studies have shown that lead poisoning can also occur at low dose environmental exposures that were initially thought to be harmless.[25] This goes to show that even though the toxic nature of lead has been known since the period of Classic Greece, the recent discovery of its low dose poisonous effects tells us that there's still much we can learn from its effects on human health.

People maybe exposed to lead either occupationally or environmentally, but occupational exposure to lead by mine workers is predominantly through inhalation of particulates and incidental ingestion of the mineral ore; on the other hand, populations living in the surrounding areas to the mine site maybe exposed and get contaminated through ingestion of contaminated soils, inhalation of particulates from the mine, and the consumption of vegetables that have been contaminated.

The effects of lead poisoning in children starts to become visible at dosages of 60 μg/dl or more, their common clinical symptoms usually include abdominal pain, joint

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[24] Plumlee, 400.

[25] Chukwuma, Sr, Chrysanthus. "*Environmental Lead Exposure in Africa*." Ambio,Vol. 26, No. 6, Springer (1997): 399-403, 399.
http://www.jstor.org/stable/4314625

pains, and clumsiness, which are then progressively followed by headaches and behavioral changes which can be a common sign of early encephalopathy or brain disorder; encephalopathy may also progress into alterations of consciousness, stupor (near unconsciousness), and convulsions.[26] Note also that "a high percentage of those children who recover from clinical encephalopathy [also tend to] have severe cognitive and behavioral impairments."[27] On the other hand, the impact of lead poisoning in adults commonly affects their peripheral and central nervous systems, their kidneys, and blood pressure.[28] In adults lead is mostly stored in their bones hence explaining why their blood lead levels may seem lower, but their symptoms of lead poisoning however present themselves through abdominal pain, joint pain, hypertension, severe headaches, increased intracranial pressure, central nervous system dysfunction, anemia, and kidney dysfunction; blood lead levels of more than 10 μg/dl should be considered high enough to cause harm even though clinical symptoms only start to show themselves above 60 μg/dl, just like in infants.[29]

Health sciences have shown that there is a correlation between elevated levels of lead in human blood and the resultant poor health in the affected populations exposed either at work or who live near lead mining sites and smelting sources. The toxic effects of lead on human health are now seen as a continuum that ranges from its well known high dose effects such as blindness, convulsions, encephalopathy (brain disorder), renal

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[26] Needleman, 212.
[27] Ibid.
[28] Ibid, 211.
[29] Ibid, 217.

(kidney) failure, severe gastrointestinal distress, and death, to previously unknown low dose chronic effects of lead on neurodevelopment, motor development, kidney disease, and anemia.[30]

The low dose exposures to lead that were previously thought to be safe have recently been discovered to be equally harmful.[31] The term "subclinical toxin" is used to describe the low dose harmful effects, but also important to note here, is that the underlying premise of this term is that there is a continuum of toxicity that shows how clinical effects of lead are just as harmful as its subclinical effects.[32] The obvious high dose clinical manifestations of lead poisoning mentioned above, such as kidney failure and brain disorder, tend to lie in the upper echelon of the toxicity continuum, whereas are the low dose subclinical manifestations like the impairment of red blood cell enzymes, alteration of neurological functions, and fetal damage tend to be at the lower end of the toxicity continuum. It is therefore important to note that low dose lead poisoning is just as harmful as high dose poisoning, and because of this, any dosage of lead exposure should be considered potentially harmful.

Even though lead affects both male and female reproductive systems, women seem to be the most impacted by it. In men, and mostly due to occupational lead exposure, their reproductive system is affected by a show of decreased sperm count and teratospermia, where as in women they experience a high incidence of stillbirths and

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[30] Plumlee, 401.
[31] Chukwuma, 399.
[32] Landrigan, P. J. "*Toxicity of Lead at Low Dose*." British Journal of Industrial Medicine, Vol. 46, No. 9 (1989): 593-96, 593.

neonatal deaths, but a decrease in fertility is experienced in both genders.[33] Low doses of lead toxicity in women can cause neurological damage to the fetus at concentrations as low as 15 μg/dl, this is mainly attributed to how the lead contaminated blood from the mother passes unimpeded across the placenta to her unborn child.[34]

TREATMENT FOR LEAD POISONING:

Since lead has no physiological use to the human body and that its detection in an individual is a sign of its presence in the environment, the prevention of lead poisoning should primarily focus on its elimination from the environment so as to reduce exposure; the primary focus of public health efforts in the control of lead poisoning should therefore be in its prevention.[35] Where prevention has failed the usual treatment for lead poisoning involves its frequent re-screening, nutrition counseling, and chelation (detoxing) therapy which all seek to remove heavy metals such as lead from the body.[36] For lead levels above 40 μg/dl, chelation therapy is effective in reducing the blood lead levels to about 40-50 percent of its baseline; note however that after the treatment has been concluded, the body's pools of lead, equilibrate themselves thus causing blood lead levels to rise again, and hence often requiring to repeat the chelation therapy.[37] Even though this treatment has drastically reduced the mortality rate caused by encephalopathy in children, its effectiveness on low-dose lead contamination are still unknown, and it therefore still remains that the only remedy at this time for low-dose lead contamination is prevention.[38]

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[33] Needleman, 212.
[34] Landrigan, 594.
[35] Castiglia, 134.
[36] Ibid, 135.
[37] Needleman, 217.
[38] Ibid.

Pollution Pathways of Lead in Kabwe:

Kabwe's lead deposits were discovered in 1902 and were mined up until 1994 without any meaningful government oversight that addressed the dangers of lead pollution.[39] Even though the mine is no longer operational, it has still left some parts of the city contaminated with lead concentrations that have become harmful to human health. "The dense fumes which came from [the] smelter, were rich in metallic pollutants such as cadmium, copper, lead, and zinc… These pollutants [that were emitted into] the air eventually precipitated on the ground surface... Since these metals are non-biodegradable, their pollution is long lasting and would entail [meaningful] pollution remediation strategies in the future [once the mine seized to operate]."[40] Lead pollutants are significantly toxic because of their non-biodegradability, cumulative nature, and non-physiological use in the human body.

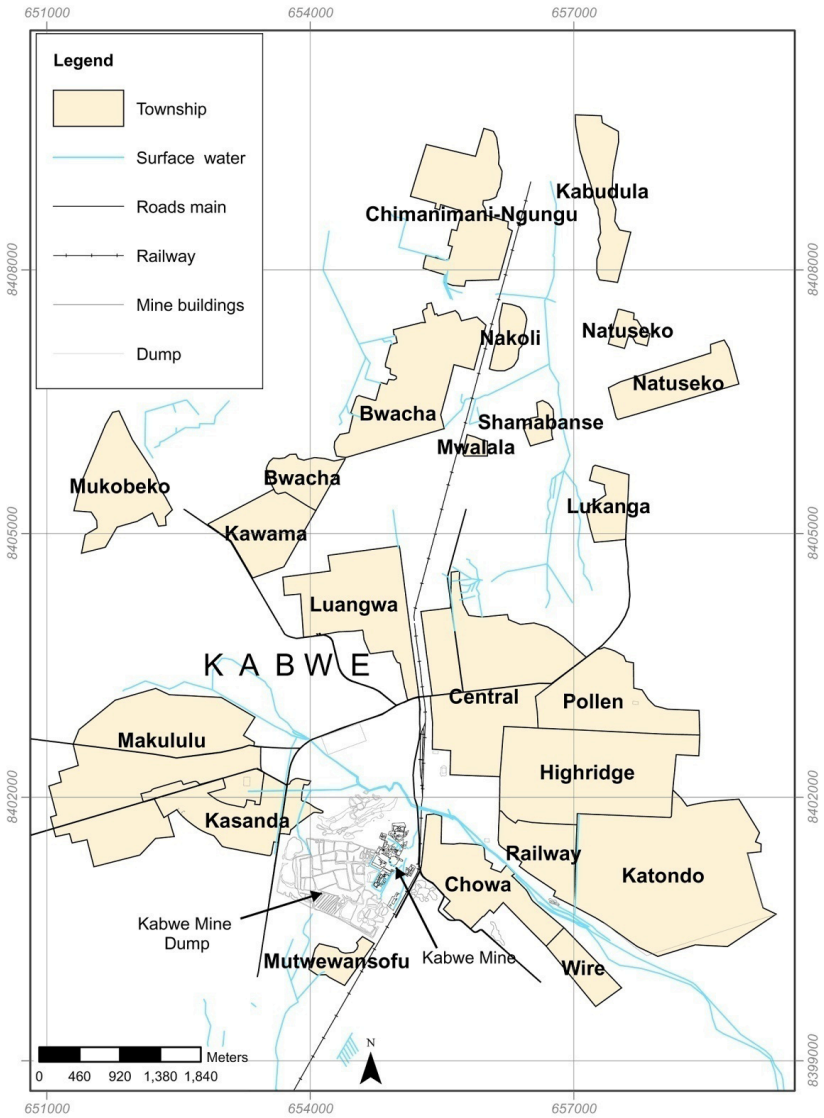
Knowledge of this lead pollution in Kabwe and its harmful effects on the local population was previously known, but not publicly disclosed by the government. In 1975 for example, a research study conducted by A.R.L. Clark from the London School of Hygiene and Tropical Medicine, indicated that the primary pollution pathways causing lead contamination from the mine included, atmospheric, soil, vegetation, and water pollution, and had predominantly affected the Kasanda, Chowa, Makululu, and Mine

[39] Blacksmith Institute, 2003.

[40] Tembo Backsion, Kwenga Sichilongo, and Joseph Cernak. "*Distribution of Copper, Lead, Cadmium and Zinc Concentrations in Soils around Kabwe Town in Zambia*." Lusaka: Chemosphere Vol. 63, no. 3 (2006): 497-501, (2014), 497.

Municipality residential areas.[41] Below in figure 1 are some of Kabwe's residential areas relative to the location of the mine:

Figure 1: Location of Kabwe Mine.



Source: Joseph Makumba/ZCCM-IH.

[41] Clark, A.R.L. *"The Sources of Lead Pollution and its Effects on Children Living in the Mining Community of Kabwe, Zambia."* (London: London School of Hygiene and Tropical Medicine (University of London), 1975), 5. http://www.blacksmithinstitute.org/projects/display/3.

Clark's research was conducted between 1971 and 1974, and at the time of his study the mining industry had just been nationalized in 1973. This study could potentially have provided the Kaunda Administration a timely opportunity to enact environmental laws that would mitigate the lead pollution that was happening in Kabwe. Kasanda Township, whose population was about 11,000 residents, was the most affected area by the lead pollution; in some part, this was because of its leeward or downwind geographical position relative to the mine and the prevailing winds that first pass through the mine before reaching this neighborhood; the township's central area is only about one mile from the mine's smelter stack, hence making it easier to contaminate the air quality over this area.[42]

During this same period, Chowa Township was a much smaller residential area with only about 3,000 residents, and because of its eastern location relative to the mine, this puts it in the windward or upwind side of the prevailing winds that blow first through Chowa and then onto the mine, hence not being subject to significant wind-blown lead pollution from the mine; and as for Makululu, this is a large squatter area which at the time of the research only had about 3,000 residents; this neighborhood is however located much further to the west of the mine and Kasanda Township.[43] It is therefore evident that a township's location in reference to the mine and the prevailing winds played a key part in determining the levels of lead pollution and contamination. Below however are the main lead pollution pathways that were observed in Kabwe:

[42] Clark, 1.
[43] Clark, 2.

ATMOSPHERIC POLLUTION:

The prevailing westerly winds that blow through the mine and onto Kasanda go unimpeded neither by trees nor buildings; these winds take up the lead particles from the effluent coming from the smelter furnace and plant stacks, and in a fumigating plume, blows them over most of Kasanda Township. The wind also tends to picks up particles from the waste ore deposited on the ground, hence contributing to the high levels of lead concentration in the air over Kasanda. Chowa Township on the other hand recorded levels within normal limits; these normal atmospheric lead levels in Chowa are attributed to its windward location relative to the mine and westerly winds that blow over Chowa prior to passing over the mine as already mentioned above. The atmospheric lead levels in Kasanda averaged 0.0968 mg/m^3 per month, which was above the U.S. standard requirement of 0.005 mg/m^3 for a 30-day period.[44] On the other hand, pollution decay due to distance travelled explains why the Makululu area, which lies further west of Kasanda and on the leeward side of the mine, experiences relatively less atmospheric lead pollution from the westerly winds passing over the mine and towards the Makululu area.[45]

SOIL POLLUTION:

As already noted, even though soil as a lead pollution pathway already occurs naturally through the lead-baring ore, much of the lead in the soil found in the four residential areas being focused on, mainly originated from the smelter stack the mine uses to emit its pollutants into the atmosphere. Kasanda Township on the other hand was an

[44] Clark, 6.
[45] Ibid, 8.

exception because it not only experienced soil contamination from the emissions settling on the ground, but more worryingly from the foundation on which the township was built. The lead concentrations found in its soils remained relatively high compared to the other residential areas because Kasanda township was built on what use to be the mine's waste rock.[46]

WATER POLLUTION:

Fortunate enough for the residents of Kabwe, water, as a lead pollution pathway is very minimal because of Kabwe's predominantly carbonate geology. Since lead is not soluble in hard alkaline water, Kabwe's carbonate geology acts as a buffer by making water hard and insoluble, hence minimizing the water contamination.[47] Water samples collected from five operating boreholes as well as from domestic taps in the supplied areas, showed lead concentrations of about 10 μg/dl; this figure is well within the current official safety limits.[48]

Even though these levels are considered normal and acceptable, the recent discovery of the low dose impact of lead poisoning should cause a policy review in official levels of lead contamination by lowering the acceptable lead concentrations levels. In the United States for example, the goal of United States Environmental Protection Agency (EPA) for acceptable lead levels in drinking water is zero; this policy

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[46] Komex International Ltd; ZCCM Investment Holdings Plc. "Zambia- Copperbelt Environment Project: Environmental Impact Assessment." World Bank Documents and Reports, E539, 2002, 2: 1-472, 127.
[47] Kamona, A.F., and G.H. Friedrich. *"Geology, Mineralogy and Stable Isotope Geochemistry of the Kabwe Carbonate-Hosted Pb-Zn Deposit, Central Zambi*a." Ore Geology Reviews, 2007, 30: 217-243, 218.
[48] Clark, 16.

was motivated by studies that showed the association of low dose blood-lead levels in children to their health and intelligence impairment.[49] The city of Kabwe should also consider emulating this policy even though its hard water prevents the problem of lead solubility.

VEGETATION POLLUTION:

Certain types of plant species are capable of acting as lead pollution pathways. Depending on the type of plant and specie, the quantity of lead uptake, and different root systems, may vary considerably; this lead uptake also depends on the amount of soluble lead available to a plant root system.[50] "Through plant uptake, Pb (Lead) enters the food chain [which then ends up being ingested by humans through contaminated food crops]. It is argued that once Pb^{2+} is ingested, it accumulates [in the bones of its host's skeleton] and is subsequently remobilized along with the phosphates from the bones which exert a toxic effect."[51] In the case of Kabwe, the amount of soluble lead available to a plant root system is relatively small and insufficient, and since root crops tend to generally contain more lead than leaf or fruit crops, there were very few crops that were found to be contaminated with lead; the maize cob on the other hand, a popular staple food crop consumed by Kabwe residents, was found to be easily contaminated, but not from the soluble lead going through root system, but instead from atmospheric pollution.[52] Once it

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[49] Chukwuma, 399.
[50] Clark, 15.
[51] Nachiyunde Kabunga, Hideo Ikeda, Tetsuji Okuda, and Wataru Nishijima. "*Assessment of Dissolved Heavymetal Pollution in Five Provinces of Zambia*." Journal of Environmental Protection, no. 4: 80-85, (2013), 84.
[52] Clark, 15.

was discovered that the maize cobs were being contaminated due to atmospheric lead pollution, it gave a better understanding as to why ingested locally grown maize in certain areas recorded higher levels of lead poisoning than in other areas. It is a common practice among most households in Kabwe to grow a maize garden in their backyards so as to supplement their food pantry, and because of this, any backyard garden exposed to atmospheric lead pollution was likely to get contaminated.

MOTHER AND INFANT POLLUTION:

Cultural practices have also contributed to lead exposure and poisoning; for example, in Nigeria a lead based material known as *otanjere* in the local Igbo language is used for its supposed "magical" properties and also for the treatment of ophthalmologic (eye) infections.[53] In Kabwe on the other hand, a cultural practice that exposes pregnant women to lead poisoning is *geophagia*. This is a common practice in Zambia among pregnant women experiencing cravings that cause them to deliberately ingest soil.[54] These craving are generally known as *pica* and tend to have a secondary impact on infants.[55] Pica is considered to be a compulsive eating habit that can be identified in most cultures; many substances including dirt, clay, laundry starch, mothballs, ice, coffee grounds, antacids, and ashes have been identified as common pica cravings.[56] Picas therefore has different name variations depending on the substance being craved, for example, *geophagia* is a clay pica, whereas laundry starch pica is called *amylophagia*,

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[53] Nnorom, I.C., J.C. Igwe, and C.G. Oji-Nnorom. "*Trace Metal Contents of Facial Cosmetics Commonly Used in Nigeria*." African Journal of Biotechnology, Vol. 4, No. 10 (2005): 1133-138.
[54] Plumlee, 400.
[55] Castiglia, Patricia T. "*Lead Poisoning*." Journal of Pediatric Health Care Vol.9, No. 3 (1995): 134-135.
[56] Castiglia, Patricia T. "*Pica*." Journal of Pediatric Health Care, Vol.7, No. 4 (1993): 174-175, 174.

and lead pica is called *plumbophagia*.[57] Unfortunately for some of the women in Kabwe who practice *geophagia,* there is also a chance that the soil being ingested is contaminated with lead, hence classifying this type of pica as *plumbophagia*. This practice therefore plays a key role in partly explaining the lead poisoning in Kabwe among newly born babies. Once lead enters the body it accumulates in the teeth and bones of an adults, but in pregnant women the lead remobilizes in the blood, hence exposing the fetus to contamination.[58] Pica is thus a sign of nutritional deficiency.

Figure 2: Selling of Lead Contaminated Soil.

Source: Joseph Mukamba/ZCCM-IH

[57] Castiglia, 174.
[58] WHO." *Lead Poisoning and Health*." World Health Organization, 2013. http://www.who.int/mediacentre/factsheets/fs379/en/.

Between 1973 and 1974, blood samples were taken from children below the age of sixteen in Kasanda, Mine Municipality, Chowa, and Makululu, to determine the extent of lead poisoning in their blood. In the 1960s and early 1970s, the acceptable normal upper limits of lead concentrations in the blood of children in most countries including the United States and Zambia was 60 μg/dl.[59] Today however the acceptable normal levels stand at 10 μg/dl and will probably get lower due to the recent discovery of how low dose lead exposure is just as harmful. Lowering the acceptable levels for safe body-lead burdens may also be based on the fact that the natural blood-lead levels in humans is approximately 0.0016 μg/dl.[60] This fact maybe attributed to another fact that lead has no physiologic function to the human body and when ingested it tends to accumulate in the body.[61] Due to these factors, one can make a convincing case for the lowering of the current acceptable blood-lead concentrations of 10 μg/dl. When a comparison of lead concentration in the blood from the children living in Kasanda, Mine Municipality, Chowa, and Makululu was done, there were certain commonalities and differences that were observed in the sampled data.

Kasanda:

This area had the most severely affected group with lead concentrations in infants ranging between 37 μg/dl and 103 μg/dl from the time they are born to the time they reach two years; by the time they reached the age of four, there was a surprising sharp fall

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[59] Needleman, Herbert. "*Lead Poisoning*." Annual Review of Medicine Vol.55, No.1 (2004): 209-222, 213.
[60] Chukwuma, 400.
[61] Castiglia, Patricia T. "*Lead Poisoning*." Journal of Pediatric Health Care, Vol. 9, No. 3 (1995):134-135, 134.

in the concentrations to about 77 μg/dl, and as they got older there was a gradual decline to levels averaging 40 μg/dl.[62] Of the ninety one children between the ages of one and two that came through the Kasanda clinic during this period, eighty nine percent of them had lead concentrations in their blood over 60 μg/dl.[63] Even though every age group was affected in Kasanda, it was the two year olds that were severely impacted.

Since lead has no physiologic use in the human body, whenever it is detected in an individual, it's an indication that environmental pollution is present.[64] Such indications were apparent in Kasanda. In the United States for example, a major indicator of lead air pollution was the use of leaded gasoline, coupled with the discovery of low dose lead poisoning, the United States enacted laws that banned the use of leaded gasoline.[65] Kasanda township on the other hand was mainly exposed to pollution pathways caused by air pollutants coming from the fumes emitted from the mine and from soil pollution; the high lead concentrations found in the soils showed contamination even at depths greater than 1.6 feet, this finding is attributed to the township having been built on what use to be the mine's waste rock.[66] In other areas soil contamination never reached the depths that were found in Kasanda.

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[62] Clark, 22
[63] Ibid, 23.
[64] Castiglia, 134.
[65] Ibid.
[66] Komex International Ltd; ZCCM Investment Holdings Plc. "*Zambia- Copperbelt Environment Project: Environmental Impact Assessment*." World Bank Documents and Reports, E539, 2002, 2: 1-472, 127. http://documents.worldbank.org/curated/en/2002/02/3022505/zambia-copperbelt-environment-project-environmental-impact-assessment-vol-2-2-main-report

Mine Municipality:

Blood samples taken from this area were close to normal levels. The lead levels ranged from 12 μg/dl at birth, then increased to 22 μg/dl by the age of two, and then gradually decreased to concentration levels of about 14 μg/dl as they grew into adults.[67] With todays low-dose lead exposures being considered harmful, the children in this township should still be considered as being at risk. In the early 2000s two new studies also found that low dose lead concentration below 10 μg/dl in infant blood was harmful and this finding hence lowered what was initially observed to be the threshold level for asymptomatic effects from lead poisoning.[68] The symptomatic clinical effects of lead poisoning in children are however only visibly noticeable at doses of 60 μg/dl, thus any dose below this level is likely to be asymptomatic.[69]

Chowa:

At the time of the Clark research in the early 1970s, Chowa Township had just been built and about 3,000 former residents from Kasanda had also been relocated there; some of the population that had moved from Kasanda to Chowa already presented high levels of lead in their blood from lead exposures whilst living in Kasanda, and when tested again in Chowa, these results were not a true reflection of the contamination levels in Chowa because of this influx of former Kasanda residents who now lived Chowa.[70] An additional observation made in this area was the drop in blood contamination levels due to the reduced inhalation of atmospheric lead. As previously mentioned, this reduced

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[67] Clark, 23.
[68] Needleman, 214.
[69] Ibid, 212.
[70] Clark, 24

contamination can partly be attributed to Chowa's geographic location on the windward side of the mine where there is less exposure to atmospheric lead pollution that came from the mine.

Makululu:

As for Makululu, the lead concentrations levels found in the blood samples was high. The concentration levels in the two year olds was 83 μg/dl, which then fell to 35 μg/dl at the age four, and then gradually decreased between 20 μg/dl and 50 μg/dl as they got older.[71] As already noted above, one of the main reasons for these high figures was due to high atmospheric lead being emitted from the mine and blown in the direction of Makululu by the westerly winds.

It is clear from these findings that infants in all these neighborhoods under the age of four were the most susceptible and impacted by the lead pollution in Kabwe. Key reasons for this susceptibility are several, but some include their ability to easily inherit lead from their mother's blood, which is already contaminated during pregnancy. This partly explains why an infant's level of lead in its blood at birth closely matches that of its mother's lead levels. "In adults, 90% of the body lead is stored in the skeleton. Once deposited in [the] bones, lead is not easily released, except perhaps during conditions of fever, acidosis, excess intake of alcohol and malignancy, [in] young children, because of a relatively greater proportion of haemopoietic bone, [they] are less able to store lead in [their bones, and therefore], this reduced capacity of lead storage in toddlers may account

[71] Clark, 25.

for their higher lead concentrations in their blood compared to older children and adults."[72]

Besides easy contamination from their mothers, this high level of lead in an infant's blood can also in part be explained from their inability to store lead in their bones in the same manner adults are able to. Studies carried out in other countries with lead contaminated communities also showed that lead exposure peaks at the age of two in most children and then drops to lower levels as was also observed in the Kabwe cases. The medical explanation to this phenomenon can also in part be explained from studies that show the 35 day half-life of lead in the blood of its host, and because of this short half-life, blood-lead is considered to be a short-term marker in diagnosing lead poisoning and hence may misclassify earlier exposures.[73]

[72] Ibid, 54.
[73] Needleman, 213.

Post 1994 Pollution Pathways of Lead in Kabwe:

The ZCCM Kabwe Mine was officially closed on June 30th 1994 and in the following year a *Site Rehabilitation and Decommissioning Plan* was crafted for the purpose of reclaiming the land and environment to its original natural state.[74] Right before the mine was closed, an Environmental Impact Assessment (EIA) was carried out to help facilitate the privatization process by assessing how much environmental damage had been done by ZCCM. Different samples that were taken from the Kabwe Mine site and its surrounding areas revealed high levels of lead contamination through the following pollution pathways:

DRAINAGE CANAL POLLUTION:

The drainage canal from the plant site proved to be a key pollution pathway to off-site lead contamination, especially in times the canal got flooded during the rainy season. Surface run-off water from the mine plant that drained into the perimeter ditch and then directed into the drainage canal was highly contaminated; from the mine site, the canal runs along the periphery of Chowa, Railways, and Katondo residential areas, and during the rainy season, the canal often over flows into parts of these neighborhoods and hence spilling its pollutants over the land and possibly into the water wells that have been dug in these neighborhoods.[75] The canal contents not only contaminates the adjacent neighborhoods it runs along, but it also empties itself into a reed dambo or wetland which

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[74] Komex International Ltd; ZCCM Investment Holdings Plc. "*Zambia- Copperbelt Environment Project: Environmental Impact Assessment*." World Bank Documents and Reports, E539, 2002, 2: 1-472, 163. http://documents.worldbank.org/curated/en/2002/02/3022505/zambia-copperbelt-environment-project-environmental-impact-assessment-vol-2-2-main-report

[75] Komex, 123.

is the headwater source to the Muswishi River, a tributary of the Chowa River, which also discharges into the Mulungushi Dam a major water supply source 25 miles from Kabwe.[76] The lead concentration in the canal is generally not a threat to the water quality supply as long the canal is regularly dredged of its sediments and buffered by the limestone geology that prevents lead to dissolve in water.

SOIL POLLUTION:

Soil samples from different parts of Kabwe were tested for lead pollution, and data still showed high levels of lead contamination in certain areas. The neighborhoods with the greatest risk to lead pollution have always included Chowa, Kasanda, and Makululu, but the Environmental Impact Statement used for this report also included Railways and Katondo Townships; it was found that the distribution of contaminated soil was consistent with the prevailing wind direction that tends to carry and deposit lead pollutants over these areas.[77] Also observed was that lead concentrations in the soil samples dropped off sharply at depths below 1.6 feet, hence showing that the shallow nature of the soil contamination was consistent with air pollutants that settled and deposited on the ground; but Kasanda Township was found to be an exception because the lead concentrations found in its soils still remained high even at depths greater than 1.6 feet, this finding was attributed to the township being built on what use to be the mine's waste rock.[78]

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[76] Ibid, 124.
[77] Ibid.
[78] Komex, 127.

VEGETATION POLLUTION:

Brassica napus is a local plant that has been found to have the ability to extract and store lead from the soil; this plant is commonly know by the locals as "rape" and is a popular vegetable crop that is part of the local dietary makeup.[79] This plant is quite efficient in extracting lead from the soil, but because it is also a food crop, its consumption can aggravate the problem of lead contamination. Since the plant is both edible and has the ability to absorb the lead that has contaminated the soil, if planted in these contaminated soils, this crop will act as a lead pollution pathway if consumed. The crop, as already mentioned above, is a very popular food crop amongst the local Kabwe residents and because of this, it will require a lot of effort and sensitization to appeal to the locals about the dangers and risk they face in eating this crop when it has been contaminated.

[79] Ibid, 162.

Environmental Liability:

As previously noted, prior to 1991 little attention was paid to the environmental impacts of mining activities in Zambia. Pollution, environmental degradation, and its impact on public health were considered to be an acceptable trade-off to the economic benefits and jobs that mining was providing. Concern for the damage mining activities were causing to the environment were for the most part muted once ZCCM got nationalized, and because the nationalizing administration stayed in power for 27 years, their policies played a huge influence on the massive environmental mortgage that has accrued over the years. The extent of this environmental mortgage in Kabwe not only impacted the town's environmental health, but also human health. It is estimated that tens of thousands of Kabwe residents, former and present, have been contaminated by lead pollution; of particular concern however, is its impact on young children seeing that it affects their mental development and can cause serious health problems, including death in certain cases.[80]

At the time of its privatization, ZCCM had accrued a huge environmental mortgage caused from decades of mining, and if the privatization process was to succeed, this environmental liability had to be addressed promptly. Since the stakes of privatization were high, the Government of Zambia was compelled to carry out an environmental audit, and in so doing, in 1993 ZCCM set up an Environmental Services Group (ESG) responsible for reviewing all environmental liabilities that would affect the

[80] World Bank, 5.

privatization process.[81] In 1996, ESG retained the services of Steffan, Robertson, and Kirsten (SRK) to prepare an Environmental Impact Statement (EIS) for each of its twelve Mining License Areas (MLA) held by ZCCM; at the time, the EIS was to act as the initial baseline for meeting the safety, health, and environmental requirements for any immediate future investors.[82] It is also interesting to note here that the government chose to use this EIS carried out in 1996 as a baseline for future environmental impact assessment data on mining, but ignored the study that was done in the early 1970s. A serious literature review of any studies done on the pollution happening in Kabwe prior to nationalizing the mines would have given the government some form of baseline information on the extent of the damage mining was causing to the environment and human health in the 1970s.

Given to the serious nature of the environmental pollution happening and the impact it had caused to public health, some potential investors, and more specifically Konkola Copper Mines (KCM) Consortium, refused to accept the legal responsibility for these environmental liabilities that were reported in the EIS before they could accept the purchase of ZCCM's assets and operations; as a consequence of this refusal, the Government of Zambia and ZCCM-IH set a precedent through KCM for all future investors, by agreeing to retain all historical environmental liabilities associated with the purchase of ZCCM as it had done for the KCM Consortium.[83] Since the government and ZCCM-IH now retain the responsibility for potential future claims arising from past

[81] World Bank, 5.
[82] Ibid.
[83] Ibid, 6.

environmental damage, the government now requires a comprehensive program that will adequately liquidate this environmental mortgage, especially for non-operational mines like the Kabwe Mine which had failed to get privatized. The government's policy on the closed Kabwe Mine states that, "as with all closed mines, ZCCM-IH therefore retains a statutory responsibility to decommission and rehabilitate Kabwe's defunct mine sites and to maintain these sites until their final rehabilitation."[84] Assigning historical environmental liability was critical if the privatization process was to proceed.

Since the government has now decided to retain the historical environmental liability that has occurred at the Kabwe mine site, the Kabwe community should start having some kind of concern as to whether the government will actually begin to rehabilitate and restore the environment of this former mining site, because since the mine site closure in 1994, the place still remains dilapidated and abandoned. Had the government properly nationalized the mines, some liability could have been placed on the mines initial owners (Roan Selection Trust and Anglo America Corporation) and reclamation bonds for cleaning up the site could have been secured. If this had been the case, it is the opinion of this report that there would have been more aggressive measures by the government to push the mine's former proprietors to cleanup, rehabilitate, and restore this site.

[84] Komex, 46.

Progression of Environmental Regulation:

When ZCCM controlled and operated the mining industry in Zambia, there were no pollution laws regulating emissions coming from the mine, this eventually resulted into decades of unmitigated environmental degradation and more specifically, the lead pollution that has contaminated Kabwe. When the Chiluba Administration took office in 1991, there was a deliberate effort to enact new environmental laws; this change however did not mean that these new regulations would immediately fix all the environmental challenges the mining industry was causing. This would take time, and because of this, Zambia's environmental legislation had taken almost another decade to make any meaningful positive changes under the Chiluba Administration between 1991 and 2000. "[During this period, new] statutes had been [established] and reoriented to facilitate economic liberalization, while safeguarding against the potentially negative environmental consequences of this process."[85] The new environmental statutes gave adequate power to regulatory agencies to monitor and control mining related environmental hazards; but the successful enforcement of these laws have however always hinged on the development of the necessary institutional capacity and adequate funding, whose lack have often undermined the enforcement of these laws.[86]

In 1994, the National Environmental Action Plan (NEAP) was developed to provide the overarching environmental policy within the guidelines of the new environmental legislation; the NEAP had replaced the 1985 National Conservation

[85] Komex, 52.
[86] Ibid, 52.

Strategy, which had previously provided guidance to all environmental policy issues.[87] The NEAP required that the laws and regulations be regularly reviewed to ensure their consistency with the nation's wider environmental policy framework, and since its implementation in 1994, the NEAP legislative review process had been carried out in the mining, forestry, water, wildlife and fisheries areas.[88] With regards to mining, a wide variety of environmental protection laws had been enacted and integrated with a range of other Statutory Instruments (SI) and International Conventions. The relevant areas of environmental legislation and their associated Statutory Instruments that have rapidly evolved and progressed since 1991 include the following:

ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL ACT:

The Environmental Protection and Pollution Control Act (EPPCA) No.12 (1990) CAP 204, established the Environmental Council of Zambia (ECZ), which was a new national regulatory body responsible for enforcing environmental regulation and coordinating the different sectors of government agencies that were involved in environmental management; the EPPCA was also responsible for setting environmental quality standards and making the polluter responsible for meeting them, thus under the EPPCA, all effluents and emissions from mining operations were regulated through a system of permits, licenses, and fines.[89]

[87] Komex, 54.
[88] Ibid, 54.
[89] World Bank, 7.

ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS:

Statutory Instrument No. 28 (1997) also known as the Environmental Impact Assessment Regulation of 1997, is a Statutory Instrument (SI) that calls for an Environmental Impact Assessment (EIA) to be prepared for all investments that have the potential to have a major impact on the environment, and this includes mining operations; under SI No.28, all EIAs are subject to a 45 day evaluation period, and during this period they must be made available for scrutiny by government agencies, NGOs and the general public for comment.[90]

MINES AND MINERALS ACT:

The Mines and Minerals Act of 1995 (CAP 213) and its two statutory instruments of *Minerals Environmental Regulations* and *Minerals Environmental Protection Fund Regulations*, are responsible for addressing the safety, environmental, and health aspects of mining. They regulate environmental pollution in the areas where prospecting, exploration, and mining operations are being done; they also require that licensed mining operators that are closing down their mining facility to first decommission the site to a level where it does not pose any danger to public safety and health.[91]

WATER ACT:

Water Act No.198 of 1948 was the primary legislation on which water resource policies and management were based; this legislation specifies the conditions under which to use water resources by the mining industry, stipulates the procedures under

[90] World Bank, 7.
[91] Ibid.

which water rights can be acquired, and also outlines the mitigation responsibilities of polluters.[92] This Act has since been repealed and replaced by the Water Resources Management Act No. 21 of 2011.

REGULATION ON PUBLIC INFORMATION AND DISCLOSURE:

As already noted earlier on, mining projects that require an EIA are also required under Statutory Instrument No.28 to make a public disclosure and consultation of their EIA results for a period of 45 days so as to allow for public scrutiny and comment. During this period of new environmental law enactment by the Chiluba Administration, there was unfortunately no legislation proposed that required mining companies to publish or disclose information on the levels of pollution they emitted, they were only required to report this information to ECZ, which is now called Zambia Environmental Management Agency (ZEMA).[93] Even though the current law states that the public has the right to be informed of the intentions public authorities have when making decisions affecting the environment, the new Environmental Management Act (EMA) of 2011 however states that the Director-General of ZEMA, may publish information on the protection, conservation, management and utilization of the environment and natural resources as the Director- General deems necessary for public education and awareness.[94] The challenge this clause brings is the question of what the Director-General may deem as being necessary information for public disclosure. What he or she may consider

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[92] Komex, 58.
[93] Ibid, 61.
[94] EMA, "*Environmental Management Act No.12 of 2011*." Zambia Environmental Management Agency (2011), 151.
http://www.zema.org.zm/index.php/environmental-legislation.

unnecessary maybe seen by others, as being vital information the public may need to know.

ENVIRONMENTAL MANAGEMENT ACT NO. 12 OF 2011:

After the Chiluba Administration left office, Zambia's environmental regulation still continued to progressively evolve. It became apparent with the succeeding administration that new environmental issues had emerged, such as climate change, pollution from persistent organic pollutants, and electronic waste; in order to address these new challenges while at the same time enhancing the control and management of the existing ones, new environmental laws were enacted.[95] On the 12th of April 2011, then incumbent President of Zambia, Rupiah Bwezani Banda, signed into law the Environmental Management Act (EMA) No. 12 of 2011, the EMA replaced and repealed the former Environmental Protection and Pollution Control Act (EPPCA) CAP 204 of 1990; the EMA also continued the existence of the Environmental Council of Zambia (ECZ) but renamed the agency to the Zambia Environmental Management Agency (ZEMA).[96] The key changes and inclusions that the EMA has brought include the provision for Integrated Environmental Management (IEM); provision for the declaration

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[95] ZEMA, "*Environmental Management Act No.12 of 2011*." Zambia Environmental Management Agency, 2011.
http://www.zema.org.zm/index.php/environmental-legislation.
[96] UNEP, "*Zambia Has Ushered in New Environmental Law*." United Nations Environment Program. June 21, 2011.
http://www.unep.org/ozonaction/News/Features/2011/NewODSregulationinZambia/tabid/56101/Default.aspx.

of protected areas; a general increase in penalties, and the imposition of orders for remedying pollution.[97]

On the day of its assent, 12th April, 2011, the EMA was read in parliament as, "An Act [that shall] continue the existence of the Environmental Council of Zambia and re-name it as the Zambia Environmental Management Agency; provide for integrated environmental management, the protection and conservation of the environment, and the sustainable management and use of natural resources; provide for the preparation of the *State of the Environment Report*, environmental management strategies and other plans for environmental management and sustainable development; provide for the conduct of strategic environmental assessments of proposed policies, plans programs likely to have an impact on environmental management; provide for the prevention and control of pollution and environmental degradation; provide for public participation in environmental decision making and access to environmental information; establish the Environment Fund; provide for environmental audit and monitoring; facilitate the implementation of international environmental agreements and conventions to which Zambia is a party; repeal and replace the Environmental Protection and Pollution Control Act, 1990; and provide for matters connected with, or incidental to, the foregoing."[98]

INTERNATIONAL PROTOCOLS:

Zambia is a signatory to several international environmental protocols and agreements, and is therefore responsible for integrating them into its national legislation.

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[97] Ibid.
[98] ZEMA, 93.

The Legal and Enforcement Component of the Environmental Support Program in the Ministry of Environment and Natural Resources, in conjunction with the Ministry of Legal Affairs and the ZEMA, are responsible for managing the integration of these international protocols.[99] The following are the international environmental protocols and agreements Zambia is so far a signatory to:

- The Rio Declaration on Environment and Development;
- Convention Concerning the Protection of Workers Against Occupational Hazards in the Working Environment due to Air Pollution and Noise Vibrations;
- Vienna Convention for the Protection of the Ozone;
- Montreal Protocol on Substances that Deplete the Ozone layer;
- UN Framework Convention on Climate Change;
- Convention on Biological Diversity;
- Convention on Wetlands of International Importance;
- Convention for the Protection of the World Cultural and Natural Heritage;
- African Convention on the Conservation of Nature and Natural Resources;
- Statutes of the International Atomic Energy;
- Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste.[100]

[99] Komex, 62.
[100] Ibid.

Rehabilitation of the Kabwe Mine Site:

The legacy of lead pollution that ZCCM left behind is one that requires a comprehensive environmental cleanup of the affected areas. Key to the success of any current or future cleanup programs lies also in understanding that all closed mining sites that were under ZCCM, including the Kabwe Mine, are by law retained or fall under the jurisdiction and stewardship of ZCCM-IH. As per Mines and Minerals Act of 1995, ZCCM-IH retains the statutory responsibility to decommission and rehabilitate the defunct Kabwe Mine site and to maintain it until its final rehabilitation. The second point to note is that, should any prospective investor decide to buy the mine, the Mines and Minerals Act exempts the buyer from any historical environmental liabilities that may arise in the future that were caused by ZCCM prior to the sale. What this means is that whether the mine site gets reclaimed or reopened, the historical environmental mortgage caused from the decades of mining remains a liability of ZCCM-IH, implying that any cleanup programs that maybe initiated by third parties need the permission and collaboration of ZCCM-IH.

Since its closure, there have been some programs that have been implemented to remediate the lead pollution in Kabwe, one of the remediation programs was carried out by the Blacksmith Institute, an international non-profit organization that is dedicated to solving pollution problems in low-income countries. “Blacksmith has helped Kabwe’s environment by establishing a local NGO, Kabwe Environmental and Rehabilitation Foundation (KERF), whose role is to bring educational and healthcare services into each [affected] community. At Blacksmith’s urging, the World Bank [was able to provide] a

$15 million grant for [environmental remediation] purposes." [101] The type of work Blacksmith and other NGOs mostly focuses on, involves the cleaning up of the surrounding communities and not the mining site itself, which happens to be a ZCCM-IH liability and responsibility. So in order to reclaim the mine site, ZCCM-IH has proposed several plans as part of its decommissioning process of the Kabwe Mine site; it must however also be mentioned that due to underfunding, these plans were based on what had been deemed affordable for ZCCM-IH and not necessarily what was required to carryout proper reclamation:

SOURCE REDUCTION:

This was the planned effort to prevent further release of lead into the environment by completely shutting down the smelter plant, which happened to be the primary source of the lead pollution.[102] Additional actions that ZCCM-IH had undertaken to reduce further contamination that was coming from the smelter plant include:

- Fencing off the contaminated area of the former mining plant complex;
- Dredging and removal of contaminated soil from the Mine Canal;
- Covering and re-grading the Waelz Kiln dump site with coarse slag.[103]

SOIL REPLACEMENT:

This is where low-lead content clean soil is used to replace the topsoil in areas where soil contamination of lead is high; the topsoil in the affected residential areas of

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[101] Blacksmith Institute. "*Kabwe Lead Mining Pollution Risk Communication Program*." New York: Blacksmith Institute, 2004.
[102] Komex, 168.
[103] Ibid.

Chowa and Kasanda has been replaced continuously with this black organic rich *Kamakuti* soil of low-lead content.[104]

PHYTOREMEDIATION:

Phytoremediation is a term used to describe the different technologies that use plants to remediate and re-vegetate contaminated sites.[105] Generally speaking, this is a process where specific plant species are used to extract heavy metals like lead from the soil through their root system; because the lead does not degrade when taken up, it remains stored in the plant's tissue and then when the plant gets harvested for disposal, the stored hazardous waste in turn gets disposed. "There are many different types of techniques included in the term phytoremediation, [and they differ from each other based on] how each technique removes, immobilizes, or degrades its contaminants."[106] One key limitation phytoremediation may have in its application in Kabwe, is that there are very few local plant species that are capable of carrying out this process, and one of the few plants that is able to do this, also happens to be a local food crop. *Brassica napus,* also locally known as "rape," is a local plant capable of extracting lead from the soil, but because it's also a food crop, the plant risks being harvested and ingested, hence further aggravating the problem of lead contamination in the area.[107]

As already noted, the dust particles containing heavy metals from the mine's waste heaps, as well as the fumes from the smelter stacks, are a primary source of lead

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[104] Komex, 169
[105] Bolan, Nanthi, Jin Hee Park, Brett Robinson, Ravi Naidu, and Keun Young Huh. "*Phytostabilzation: A Green Approach to Contaminant Containment*." Advances in Agronomy, Vol. 112 (2011): 145-204,146.
[106] Bolan,146
[107] Komex, 166.

pollution in Kabwe. Re-vegetation of topsoil that has been contaminated with these heavy metals was not considered a viable option because the project depended on having knowledge of the original indigenous flora and other suitable plants capable of sustaining this project.[108]

One phytoremediation technique that has worked and may be sustainable is phytostabilization; this technique aims to contain soil pollutants within the subsurface by accumulating the pollutant in the plant's roots or through precipitation within the rhizosphere, a region in the soil that is controlled by the root system of a plant; what this process does is that it prevents off-site contamination through pollution pathways such as wind, water, leaching, and soil dispersion.[109] The following plant species have been considered as possible replacements to Kabwe's original plant species in experimenting with the phytostabilization technique: *Indigofera spicata, Melinis repens, Cynodon dactylon, Aristida adscensionis,* and *Pennisetum setaceum*.[110]

COMMUNITY EDUCATION:

In some instances, the prevention of social and health problems can only be achieved by influencing behavioral change amongst the general public through proper public education. Educating the public on an issue can result into effective domestic behavioral changes and environmental movements that compel political actors to help resolve these issues by enacting adequate laws.[111] The affected communities and the city

[108] Leteinturier,627.
[109] Bolan, 146.
[110] Leteinturier, 626.
[111] Chukwuma, 401.

at large needs to be sufficiently educated about the decades of pollution that has been happening in Kabwe and the effects it has had on both human and environmental health. Through outreach programs, the local communities, can, and are beginning to get information about the harmful effects of lead contamination.

As already mentioned earlier on, NGOs such as the Kabwe Environmental and Rehabilitation Foundation (KERF), have already started to sensitize and educate the local communities about the harmful effects of lead poisoning through their education and healthcare service programs. Below in Figure 3 is an illustration of the kind of effort being made in creating public awareness through the construction of public information centers. Kabwe's Town Center library is one of few information centers being used as an Environmental Public Information Center (EPIC) for the outreach program run by the Copperbelt Environmental Project and Zambia's environmental protection agencies. These information centers are also located in Kasanda, Katondo, and Makululu residential areas.

More importantly than just educating the public on the harmful effects of lead poisoning, new laws need to be enacted that allow for full public disclosure on the types and quantities of pollutants that are being emitted into the environment by the mining companies, currently such disclosures are only made available to ZEMA, Zambia's principal environmental agency.[112] Public awareness and access to environmental information is cardinal to the reclamation process in Kabwe, this will not only encourage the public to participate in environmental discussions happening in their communities,

[112] Komex, 61.

but they can also enable them to oppose any activities that may threaten their environment and health.

Figure 3: Public Information Center.

Source: Joseph Mukumba/ZCCM-IH

SUPERFUND PROGRAMS:

In the United States, the Environmental Protection Agency (EPA) among other things also manages what are known as federal Superfund Sites; these are locations that have been polluted by toxic chemicals that the government has determined it will have to remediate because responsibility as to who caused the pollution has not been fully determined, and consequently whose funding for such a cleanup has not been secured.[113] These sites tend to be uncontrolled or abandoned and whose hazardous waste could, or is already affecting the local ecosystem or its people.

[113] Sansom, Andrew. "*Water In Texas*". 1st ed. Vol. 1. Austin: University of Texas Press, (2008): 163.

In 1980, The United States Congress established the Superfund Program to locate, investigate, and remediate the worst polluted sites in the country; the EPA administers the program in collaboration with the individual states and tribal governments in which these sites are located.[114] The EPA does not just seek to clean and reclaim the site, but even more important, it seeks to make the site productive again to its community; because of this intent of returning sites to being productive again, the programs responsible for achieving this include: the Brownfields Program, Superfund Redevelopment Initiative, and the Land Revitalization Initiative.[115]

Even though the Zambian government has assumed liability for all historical environmental pollution caused by the mining industry, further provisions should be made for a program analogous to the superfund program and its associate programs that return sites to being productive again, as is the case in the United States. The closed Kabwe Mine currently shows signs of abandonment, but regardless of this circumstance, toxic waste materials still exist in the environment and continue to be a threat to the human population. Implementing a superfund program will therefore not only help in cleaning up the lead pollutants in Kabwe, but also help to restore and make the reclaimed site useful again to the Kabwe community.

This report is not in any way trying to undermine the progress and effort being made by the Zambian Government in trying to improve the environmental and mining laws, what it is instead recommending, are further enhancements or amendments of its environmental laws as they pertain to legacy pollution and how to deal with unrehabilitated pollution sites owned by the Government like the one in Kabwe. In all

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[114] EPA. "*About Superfund*." United States Environmental Protection Agency. http://www.epa.gov/earth1r6/6sf/6sf.htm.
[115] Ibid.

fairness the Mines and Minerals Development Act of 2008 has made provisions for an Environmental Protection Fund whose purpose partly includes cleaning up sites contaminated by the mining operator. This provision states, "there shall be an Environmental Protection Fund, which shall be administered and managed in such a manner as the Minister may, by statutory instrument, prescribe."[116] The only concern this report has with this provision is that too much latitude has been given to the Minister in how to use this fund and that it remains silent on oversight provisions. Secondly, the question of mining operators who file for bankruptcy prior to cleaning up the pollution they caused has also not been adequately addressed. Finally, this provision does not speak of how to make the site productive again to its community after it has been remediated.

In the U.S. the Zortman-Landusky Mine, located in Northern Montana, leached cyanide and acid into nearby waterways, polluting not only the waterways, but also both the surface and subsurface of the land; the company that developed this mine, Pegasus Gold, later filed for bankruptcy, hence leaving the burden of cleaning up the site to the local communities, state, and federal authorities.[117] Through such cases the Zambian government can see how the superfund program works and how through the use of reclamation bonds it can create a similar program, if not better. Reclamation bonds, as the report will show later on, are targeted financial instruments that help fund a specific remediation program.

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[116] MMDA, "*The Mines and Minerals Development Act of 2008.*" Government Printers (2008): 133.
[117] Emel, Jody and Rob Krueger. *"Spoken but not Heard: The Promise of the Precautionary Principle for Natural Resource Development,"* Local Environment, Vol. 8, No. 1, (2003): 15.

PRECAUTIONARY PRINCIPLE:

One of the guiding principles in the Environmental Management Act (EMA) of 2011 is the precautionary principle. The Minister in charge of environmental management in Zambia may by statutory instrument, and on the advice of the Agency (Zambia Environmental Management Agency), make new environmental regulations.[118] In the event that there is no absolute or conclusive scientific proof to the degree of toxicity or the hazard posed by any substance contaminating the environment, the new regulations made by the Minister shall refer to the precautionary principle as the rationale for doing so.[119] Therefore, for current and future mining development projects, it is the opinion of this report that the Government of Zambia should enhance and instill the *precautionary principle* as a corner stone practice in all its environmental policies and implementing agencies, especially in those agencies that are involved in environmental management. Such a policy would help mitigate or avoid any future pollution disasters as was experienced in Kabwe.

In Zambia, mining development has not escaped the common narrative also experienced by other natural-resource-rich developing countries. This is the experience where natural resource development predominantly only provides short-term benefits such as jobs and tax revenues at the expense of long-term environmental and community degradation; the *precautionary principal* provides an opportunity to local communities and others who live near mining areas to advocate for a cautionary approach to mine permitting so as to prevent any harm and loss suffered by these residents due to the pollution coming from the mine.[120] The precautionary principle embodies a conservative philosophy that admonishes one to be cautious where risk to people and the environment

[118] EMA, 102.
[119] EMA, 129
[120] Emel, 9.

is uncertain, damaging, or irreversible.[121] At the core of the *precautionary principal* is the premise that action should always be taken to prevent any harm to the environment and human health regardless of whether the scientific evidence needed to support environmental protection is inconclusive or not.[122] In retrospect, if this principle had been applied in the Kabwe mining operation, mining development would have been better managed and the lead pollution that has contaminated the city would have been prevented.

RECLAMATION BONDS:

In the United States the Surface Mining Control and Reclamation Act of 1977 (SMCRA or the Act) stipulates that, as a prerequisite for obtaining a coal mining permit, an applicant must post a reclamation bond that ensures the regulatory authorities to have enough funds that will reclaim the site should the permit holder fail to complete the reclamation plan approved in the permit.[123] A company's reclamation bond should be large enough to cover the remediation cost; otherwise if the company files for bankruptcy the burden of cleaning up is left to the government and local communities. In Zambia, the mining permitting process does not require the acquisition of a reclamation bond prior to the applicant being granted a mining permit, the only requirement the permit holder is expected to meet is the pledge that if they cause any environmental damage during and after their mining operation, they would remediate any damage caused.[124] Additionally, if a licensed mining operator decides to close down their mining facility, they are required by law to decommission the site to a level where it does not pose any danger to public

[121] Ibid, 10.
[122] Ibid, 13.
[123] OSMRE. "*Reclamation Performance Bonds*." Office of Surface Mining Reclamation and Enforcement, U.S. Department of Interior (2014). http://www.osmre.gov/resources/bonds/BondsOverview.shtm.
[124] MMDA, 131

safety and health.[125] Reclamation insurance in Zambia is therefore not required before the permit is issued. If the previous operators of the Kabwe Mine had been required to take out a reclamation bond prior to being issued a mining permit, the lead pollution that has contaminated this town would have been in principle by now cleaned up.

The only cleanup assurances given by the permit applicant prior to being granted a permit under the Mines and Minerals Development Act of 2000 are cash payments from permit applicants that are deposited into the Environmental Protection Fund.[126] The law further states that cash deposits shall be paid into the Fund, and that moneys from the Fund may be applied as follows—at the expiry or termination of a license or permit by way of refund to the permit holder of the same amount of cash deposited but only to the extent that such moneys are not appropriated to the payment of any debt owed by the permit holder.[127]

As can be noted, it is only these cash deposits placed into the Environment Protection Fund prior to granting new permits that imitate reclamation bonds. However, "where any harm or damage is caused to the environment or biological diversity, [after the permit has been granted], compensation shall include the cost of reinstatement, rehabilitation or remediation measures which are incurred and where applicable, the costs of preventive measures by the permit holder."[128] It is therefore the opinion of this report that reclamation bonds would be a better mechanism to securing funding for remediation of mining sites prior to permits being granted, as opposed to the current system that does not guarantee sufficient cleanup funds during the permitting process.

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[125] World Bank, 7.
[126] MMDA,131.
[127] MMDA,133.
[128] Ibid,134.

Conclusion:

Even though the Kabwe Mine has been closed and the levels of pollutants being emitted into the environment have in principle stopped, this does not mean that the local population is still not at risk to lead poisoning. From the findings of this report, it appears that Kabwe residents are still at risk from low dose lead poisoning that was initially thought to be harmless. The closure of the Kabwe Mine is therefore not sufficient to prevent low dose asymptomatic injury caused by lead. Any reclamation projects should therefore focus on reducing not only the high dose lead poisoning, but also the harmful effects of low dose lead poisoning; the current acceptable lead concentrations for blood contamination is at 10 μg/dl, lowering this level would tremendously reduce low dose lead poisoning, especially in Kabwe. This is a town that has previously recorded lead concentration levels in human blood that averaged between 60 μg/dl and 120 μg/dl. With the mine having been closed in 1994, these averages could potentially have dropped to lower levels by now, but are still to be considered harmful.

The discovery of low-dose lead poisoning also implies that new laws need to be enacted, because the current regulations do not accommodate for this type of lead poisoning. New regulations should make provisions for new standards that reduce the permissible levels of both occupational and environmental levels of exposure to lead. A second set of legislation that needs to be amended is the Mines and Minerals Act regarding its permitting requirements. New provisions should be made requiring that all applicants should take out a reclamation bond sufficient enough to cover the remediation

and reclamation costs prior to being granted the mining permit. These are therefore the immediate changes this report recommends.

The question this report began with, was one that sought to understand the underlying factors that caused the high levels of lead pollution in Kabwe. This report concludes that the root cause to Kabwe's lead pollution was fundamentally a question of nationalization policies that did more harm than good for the human and environmental health of Kabwe. In some developing countries, the economic pressure and the lack of financial resources has led to the negligent development of their natural resource industries, hence polluting the environment with little incentive being given to improve or protect it.[129] Like most governments in developing countries with natural resources, Zambia also focused its policies mainly on job creation without much emphasis on environmental protection, so in order to understand how Kabwe became one of the most polluted places on the planet, it is therefore the opinion of this report that the one-party state system of government and its nationalization policies, played a key role in stunting the growth of Zambia's environmental consciousness and policies. Nationalization created an environment where lead pollution went unmitigated for decades and the one-party state system of governance re-enforced this. When multi-party politics were introduced, the new administration enacted new environmental laws and privatized the mines. It was during the privatization era, that Zambia saw progressive environmental laws, public sensitization to the lead pollution, and the assigning of liability to the environmental damage that had been caused by the mining industry.

[129] Chukwuma, 399.

Understanding the timeline between the era of nationalization and privatization also further helps one to understand why lead pollution went unmitigated for decades. When Zambia gained its independence in 1964, Kenneth Kaunda became its first president, who as earlier noted, was also responsible for instituting nationalization policies and the one-party state system of government. Due to these factors, Kenneth Kaunda was able to rule for 27 years, and it's in those 27 years that his government created policies that induced an environment where lead pollution in Kabwe went unmitigated. The legislation of new and meaningful environmental laws only occurred after 1991 under a new administration led by Frederick Chiluba. This new administration ushered in new economic and environmental policies that ended nationalization and initiated pollution mitigation policies respectively. Unfortunately, the timeline between the eras of nationalization and privatization was too long and damaging for environment, and because of this lapse in time, this in part explains the decades of environmental pollution in Zambia and more specifically, the lead pollution in Kabwe that gained it notoriety as being one of the most polluted places on the planet in a 2007 *Time Magazine* article. This is therefore my account to understanding Kabwe's lead pollution.

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